PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-153437
(43)Date of publication of application : 28.05.2002

(51)Int.Cl. A61B 5/05

(21)Application number : 2000-351445
(22)Date of filing : 17.11.2000

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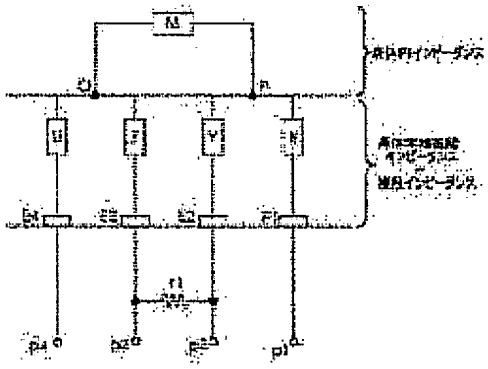
(54) BODY IMPEDANCE MEASURING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To respectively independently extract and provide a value for which the impedance of a body end tissue peripheral part is included in the contact impedance of an electrode and a body end tissue skin surface together with the value of a conventional intra-body impedance.
SOLUTION: A current path having finite electric conductivity is formed by connecting a resistor r1 between at least two electrodes E2 and E3 among a plurality of the electrodes E1-E4 in direct or indirect contact with the body skin surface at the two parts of the body skin surface. A measuring circuit is constituted so as to make both electrodes apply a current at least once in a measuring process.



ACQUISITION AND ANALYSIS OF ELECTROMYOGRAMS OF THE HUMAN MASSETER MUSCLE

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ABSTRACT

The electromyograms from the human masseter muscles of a randomly sampled population were obtained to determine if there was a signal characteristic of those EMG's which could be used to accurately distinguish among the signals generated for some related mechanical activities. A custom designed variable gain EMG preamplifier/signal conditioner was constructed to sense and amplify the signals which were digitally sampled, stored, and analyzed. Various time and frequency domain characteristics were estimated and equivalence tests were performed on combinations of the power spectra. Distinctions in the characteristics of different activities on the whole were not clear-cut. However, it was found that the spectra for clenching and chewing activities of the dysfunctional persons in the test group were measurably different from the average statistics of the group.

INTRODUCTION

Bruxism, i.e., the habitual clenching and/or grinding of the teeth, has been shown to have a definite psychological link and that the application of biofeedback techniques to control it are moderately successful [1]. Unfortunately, the EMG monitoring devices used in previous work have been based on the principle of integrating or averaging the signal and indicating bruxism via threshold detection. This approach therefore will also "alarm" the subject during normal activities such as chewing. The purpose of this work was to search for a signal characteristic that could be used to accurately distinguish bruxism EMG's from other related EMG signals.

EXPERIMENTAL AND COMPUTATIONAL METHODS

A specially designed EMG preamplifier/signal conditioner system was constructed to ensure proper detection of the EMG signals. The system utilized ultra low-noise matched operational amplifiers in the first stage to establish a minimum signal-to-noise ratio of 38 dB. Battery operation was chosen to eliminate the need for isolation circuitry and to remove a large source of 60 Hz noise, namely, power lines. Therefore, to conserve power, micropower op-amps were used in subsequent stages and the system power was derived from two 9 volt batteries using micropower regulators. The remainder of the 60 Hz interference and other common mode noise signals appearing on the body surface was significantly reduced by employing a driven common circuit. A bandwidth of 5 to 500 Hz with a rolloff of -80 dB per decade for both skirts was achieved with cascaded second-order Butterworth filters. The cutoff frequencies were determined from initial unfiltered tests using a sampling rate of 10 kHz and are consistant with the literature [2]. The gain was adjustable in calibrated steps, selected with a pushbutton control through a 16 channel analog switch that was placed in the feedback loop of a modified differential amplifier [3]. This provided a voltage gain range of 58 to 114 dB. The system was fully shielded in an aluminum case and well grounded.

The EMG's were obtained from 18 randomly selected volunteers. A questionnaire was administered to each subject and it was found that 2 of the volunteers were diagnosed bruxers, 5 indicated that they were aware of a potential for bruxism, and the remainder indicated no conscious parafunctional activity. The skin surface was cleaned with disposable abrasive pads and washed with alcohol. Reusable 8 mm Ag/AgCl surface electrodes with shielded leads were placed over the masseter muscle, with the common electrode placed symmetrically between the two input electrodes to further minimize common mode interference [4]. For each subject, four data records were taken during four different, but related, mechanical activities: a 20 mm bite separation sequence, a 2 mm bite separation sequence, a clenching sequence, and a chewing sequence. For the bite separation sequences, the subjects were instructed to bite on wooden spacers; for chewing, gum was used because of its relatively uniform consistency. The amplified signals were sampled at 2 kHz via a PDP 11/23 computer system and stored as 4.096 second (8192 points) data records on diskettes. The data was then transferred to a VAX 11/780 computer and analyzed with custom designed FORTRAN routines.

The EMG's were assumed stationary [2] and standard signal processing techniques were used to estimate various signal parameters [5]. The quantities estimated for each record of each

IEEE ENGINEERING IN MEDICINE & BIOLOGY SOCIETY 10TH ANNUAL INTERNATIONAL CONFERENCE—1135
CH2566-8/88/0000—1135 $1.00 © 1988 IEEE

subject were the RMS signal strength, the maximum signal strength (as peak values), the power spectral density (from an FFT), the mean power frequency, and the spectral deviation, or dispersion of the signal. The number of samples taken, combined with a time segmentation averaging technique (32 segments per record) ensured an acceptable level of random error (.17%) and variability (± 3.1 dB) for the spectral estimates and a small amount of variability (± 1.1 dB) for the RMS estimates with 95% confidence. An equivalence test based on the chi-square goodness of fit test was performed on the normalized spectra for each activity type and equivalent spectra for each activity type were pooled to form "average" spectra. Finally, equivalence tests were performed on the pooled spectra among the different activity types to determine if the "average" spectra for different activity types could be considered distinct, particularly for clenching.

RESULTS

It was found that for the individual data records, definite upward trends in signal strength and mean frequency were apparent for the clenching activity when compared to the other three activities. However, neither of these characteristics were significantly different among the four activity types to facilitate accurate detection of bruxism; that is, the standard deviations for the group of individual statistics were too disperse. The majority of the individual normalized spectra for a given activity tested equivalent to each other at the $\alpha = 0.005$ level of significance and could be pooled. The spectra which did not test equivalent to the majority were those obtained from the diagnosed and potential bruxers, particularly for the clenching and chewing activity types. This suggests that spectral techniques could be used to detect or evaluate parafunctional activity in individuals. While the pooled spectra again demonstrated an upward shift in the mean frequency for clenching, the equivalence tests performed among the pooled spectra for the four activities indicated that the difference was not statistically significant to allow accurate detection of bruxism.

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